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Central Solar (District) Heating Plants

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Introduction

Denmark has a leading tradition for large-scale solar heating connected to district heating, short CSHP. Such plants can include any type and size of seasonal storage, whereas the pit water storage seems to be the cheapest and most promising thermal storage technology for large-scale applications.
In 2012 a first full scale demonstration was presented in Marstal, Denmark. Today the plant is grown to over 33.000 m2 of solar collector and a storage capacity of over 85,000 m3 pit water storage..

District Heating in Denmark

In Denmark, DH has been actively promoted as an important component in the national strategic energy planning. Denmark has 670 CHP plants and 77% of total DH and 55% of electricity come from CHP plants (Fig 2). Over 50% of total heating supply in Denmark comes from DH and around 62% of residential buildings connect with DH.

Fig. 1: Central Solar Heating Plants (CSHP) in Denmark

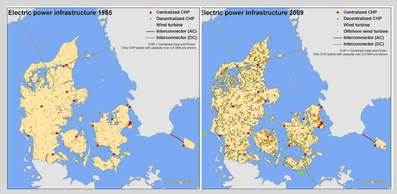

Fig. 2: CHP plants in Denmark

The overall plant schema

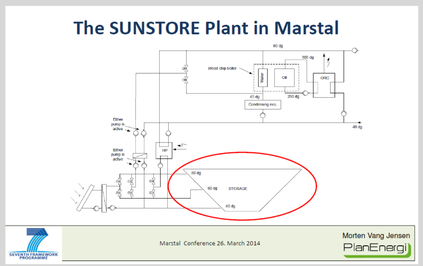

Fig. 3: The plant layout, schematically, collector array (loop), storage loop, boiler loop and district heating loop.

The basic configuration of central solar heating systems and its connection to the district heating is shown in (Fig. 3).
The collector field involving anti-freeze liquids. Hence a heat exchanger is necessary to deliver the heat to the district heating loop and the storage loop.

Fig. 4: Examples of solar fields: (a)Terrain mounted, (b) solar field, (c) roof mounted: Source: http://www.solar-district-heating.eu

The heat store

Fig. 5: The plant with storage under construction.

World larges pit water storage is present at the Marstal:

- Built 2011-12
- Size: 75,000 m^3 water
- Price 2.65 mio. € excl. transmission pipe or 35.5 €/m^3 or 0.38 €/kWh
- Temperatures 10 – 90^{o}C
- Capacity: 6,960 MWh
- Charge and discharge capacity: 10.5 MW
- Calculated heat loss: 2,475 MWh/year

The Floating Lid Construction

The insulated lid is floating on the water surface avoiding a static construction and hereby a very cheap solution. (Fig. 6).

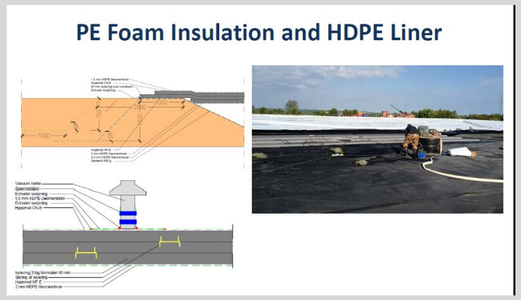

Fig. 6: The floating lid construction.

Fig. 7: Pit construction: (a) digging (b) establishing shape (c) lining with plast foil. Source: http://www.solar-district-heating.eu

The Heat Pump

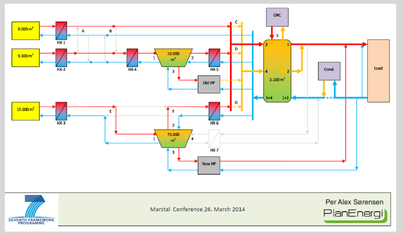

Fig. 7: The system layout.

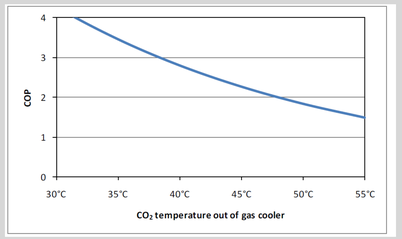

Fig. 8: Efficiency of heat pump.

There are involved 2 heat pumps as shown in (Fig. 7)

	MWh/year
9,000 m2	3,383
9,300 m2	3,727
15,000 m2	6,435
Collectors total	**13,545**
Propane heat pump	214
CO2 heat pump	1,043
Heat pump total	**1,257**
ORC	12,023
Scrubber	4,008
Wood chip total	**16,031**
2,100 m3	-119
10,000 m3	-520
75,000 m3	-2,193
Store losses total	**-2,833**
Bio oil	4,000
Total	**32,001**

Fig. 9: Production data – computations.

Heat pumps are utilized for half of the year in winter periods with no seasonal storage, or low temperature in storage.

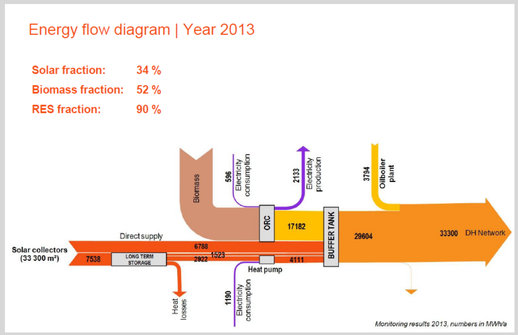

Fig. 10: The system layout. Source: Schmidt T., "Sunstore 4, Monitoring results 2013.

Energy balance for the year 2013 monitored. The solar share is 34% even with a large-scale seasonal storage.
Flexibility opportunities are very large.

Further Information

A European Cooperation with web site: http://www.solar-district-heating.eu
Project Sunstore 4: http://sunstore4.eu/newsroom/events-presentations/
Web Blog: http://centralsolarheating.wordpress.com/

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